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POPULATION DECLINES OF THE PUERTO RICAN VIREO IN GUÁNICA FOREST

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ABSTRACT.—Abundance of the Puerto Rican Vireo (*Vireo latimeri*) in Guánica Forest, Puerto Rico, has declined gradually over the period 1973–1996 as determined by constant-effort mist netting. Concurrent studies of breeding vireos show low nesting success, primarily due to parasitism by Shiny Cowbirds (*Molothrus bonariensis*). This decline may reflect the rather recent entry of the cowbird into Guánica Forest during the breeding season, as other factors (vegetation change, rainfall) do not seem to explain the decline. As a single-island endemic, it is important that the cause of this decline be determined so that recovery efforts can begin while the species is still moderately abundant. *Received 7 May 1996, accepted 10 Oct. 1996.*

We have monitored birds in Guánica Forest, Puerto Rico, since 1973, first with a single mist net line (1973–1996), then with multiple lines (1989–1996). Here we present evidence of a decline in abundance and possible declining survival rate of the Puerto Rican Vireo (*Vireo latimeri*) during the period 1973–1996. These patterns may be explained in part by the low reproductive success which has been found in this species in recent years, primarily due to parasitism by the introduced Shiny Cowbird (*Molothrus bonariensis*; Woodworth 1995). We discuss the possible factors causing these declines in this forest. Because the Shiny Cowbird has become widespread on the island only in recent years, we feel these trends may reflect island-wide declines of this single-island endemic.

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STUDY AREA AND METHODS

The Guánica Forest of southwestern Puerto Rico is a 4000-ha reserve comprised of subtropical deciduous forest on a limestone substrate (see Terborgh and Faaborg 1973 for a detailed description with photographs). It has been protected for over 60 years by the Commonwealth of Puerto Rico and is designated a United Nations Biosphere Reserve. About half of the reserve has relatively undisturbed forest, while the remainder is 60-year-old or older second growth.

Monitoring of bird populations has been done for 23 years using lines of mist nets operated from dawn to dark for three consecutive days (Terborgh and Faaborg 1973, Faaborg, in press) in January or early February. A single line of 16 nets (each 12 m long, 36 mm mesh, 2.6 m high) strung end-to-end has been operated annually since 1973 (except 1977 and 1979). In 1989, more intensive netting was begun, with a total of seven 16-net lines in 1989, an additional line added in 1990, and another line in 1991, resulting in nine lines during 1991–1996. Lines are run in the exact location each year, such that we have one 23-year sample, six eight-year samples, one seven-year sample, and one six-year sample. Because capture rates are low by the third day, we feel these constant-effort samples provide a good index of relative population size when compared from year to year. Here, we report total captures of vireos by net line for the three-day sampling periods.

The Puerto Rican Vireo is well suited to population monitoring and survival estimation by use of mist nets. It forages in thick vegetation within the height of the nets (<2.5 m; Cruz and Delannoy 1984), so it is easy to capture with regularity. Vireos are territorial throughout the year, show low dispersal rates from territories, and have high potential longevity (as high as 13 years, 2 months; Woodworth 1995). Territories are approximately 200 m across (Woodworth, unpub. data), so one to three territories could overlap one net line. The net lines provide independent samples, as a vireo has never been caught in two lines within the same year. Given these traits and the fact that a single species is involved, we feel we have avoided all the problems associated with mist-net capture data as discussed by Remsen and Good (1996).

All birds captured were banded and immediately released, with recaptures recorded over time. We recorded the net in which captures took place in order to determine dispersal and territorial behavior. These recapture data allowed us to estimate survival rates using the program JOLLY (Pollock et al. 1990). We compared survival estimates of Puerto Rican Vireos for the following time periods and sample efforts: the single, original net line for 17 years (1973–1990; Faaborg and Arendt 1995), the single, original net line for 23 years (1973–1996), and eight new net lines for seven years (1989–1996).

The appropriate model was selected for each of these data sets using Chi-square goodness-of-fit tests and likelihood ratio tests between models whenever possible (Pollock et al. 1990). Models that generated estimates with the lowest coefficients of variation were chosen when there was insufficient data to perform goodness-of-fit tests. Model D, which assumes constant survival and capture probabilities, provided the best estimates of survival for the original line during 1973–1990 (Faaborg and Arendt 1995) and during 1973–1996. Model B, which assumes constant survival rates and time-dependent capture probabilities, provided the best estimates for the new lines during 1989–1996.

RESULTS

All of the measures of total captures or capture rates for the Puerto Rican Vireo for the period 1973 to 1996 suggest declining populations. The original net line never caught more than four individuals per sample

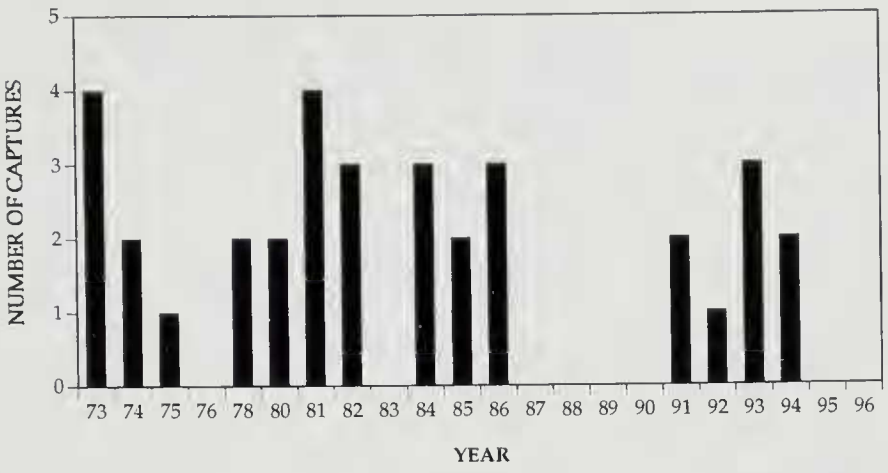

FIG. 1. Captures of Puerto Rican Vireos on the original Guánica net line during 1973–1996.

(Fig. 1), but the occurrence of no captures in six of the past 10 years (in contrast to two of the first 12 samples) suggests a local population decline. A regression of these data suggests about a 5% annual decline ($y = -0.0673x + 7.2748$; $R^2 = 0.1155$). The seven net lines that have been operated annually for the period 1989–1996 show a decline from 27 total captures in 1989 to as low as eight captures in 1995 (Fig. 2). While there was a slight increase in captures in 1996 (10), it is interesting to note that

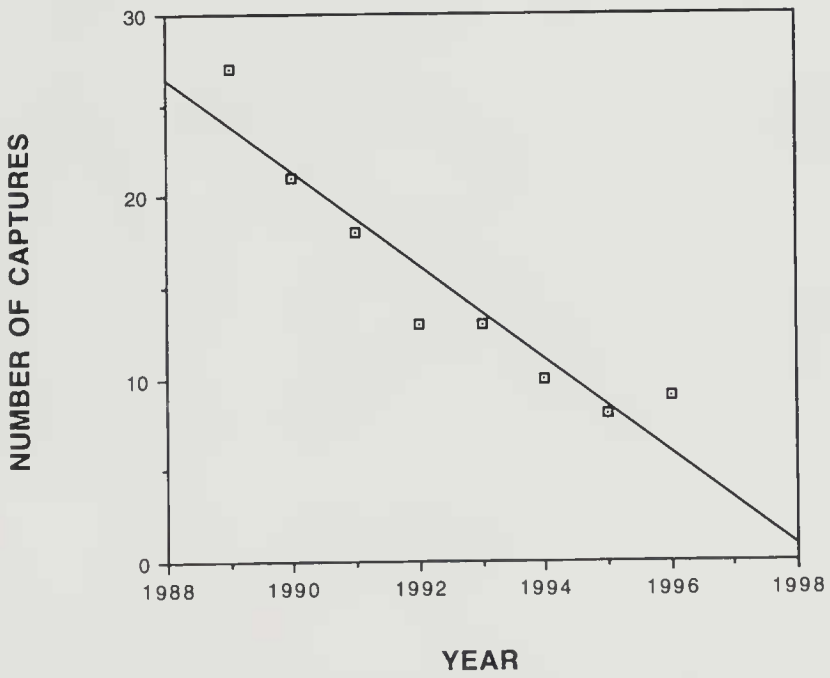

FIG. 2. Total captures of Puerto Rican Vireos annually on the seven net lines operated during the period 1989–1996 ($Y = 2.5595X + 5114.7$; $R^2 = 0.8966$).

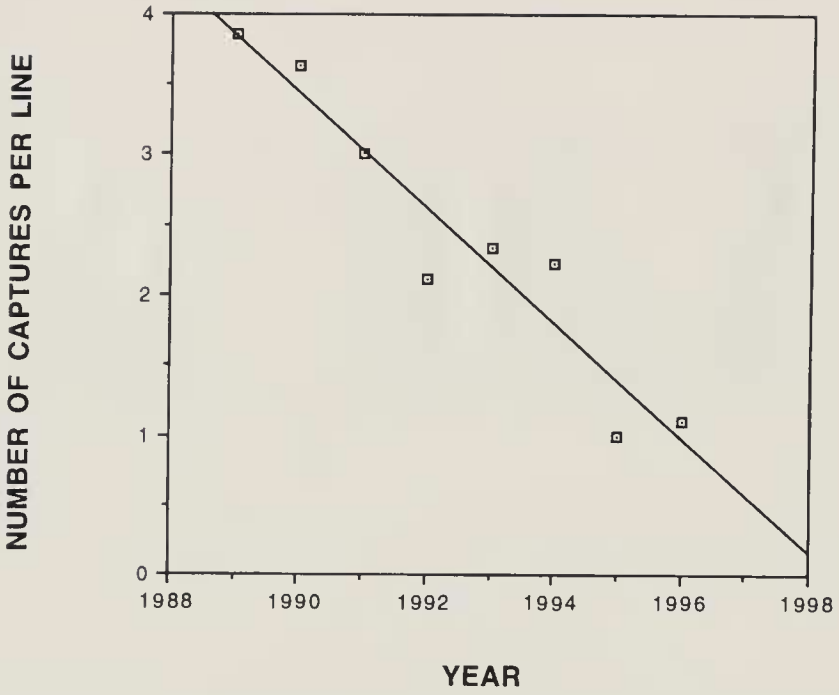

FIG. 3. Capture rates of Puerto Rican Vireos measured as mean vireos captured per net line for all net lines operated during the period 1989–1996 ($Y = 0.4101X + 819.57$; $R^2 = 0.915$).

nine of these birds were recaptures of birds banded in prior years. Mean captures per net line (for seven, eight, or nine lines annually) also shows a marked decline during 1989–1996, with nearly four birds caught per netline in 1989 and less than one in 1995 (Fig. 3).

Our estimates of annual survival for Puerto Rican Vireos have declined somewhat since the beginning of this study, although differences are not statistically significant. This trend is strongest for the birds captured in the original net line, with survival rate estimates declining from 0.68 (±0.08; Faaborg and Arendt 1995) during 1973–1990, to 0.61 (±0.08) when six more years of recapture data were added (1973–1996). During 1989–1996, survival estimates for the new lines were 0.63 (±0.06). An analysis done after the 1994 banding season suggested severe declines in annual survival rates (0.54 ± 0.06), but during 1995 and 1996 we captured four individuals which had not been seen for three to six years, which raised the survival rate estimate.

DISCUSSION

The results from intensive mist netting suggest that the population of Puerto Rican Vireos in Guánica Forest declined during the period 1973 to 1996, with evidence for a forest-wide decline during 1989–1996. Furthermore, estimates of survival rates suggest that mortality or emigration

has increased in recent years. The decline in numbers of vireos may be the result of a decline in reproductive success due to increased brood parasitism rates, increased predation, or environmental factors. The Shiny Cowbird, a generalist avian brood parasite, first arrived in northeastern Puerto Rico in 1955 (Grayce 1957). A study of reproduction by the Puerto Rican Vireo during 1990–1993 has documented low reproductive success in this species (Woodworth 1995), primarily due to parasitism by the introduced cowbird. Of 98 active nests, 83% were parasitized, and parasitism decreased vireo reproductive success by 82%. Only 5% of active nests fledged vireo young. Breeding pairs made as many as six nesting attempts per season, resulting in only 0.24–1.33 vireo young per female per year. Population models show that prior to the cowbird's arrival in Guánica Forest, this population of Puerto Rican Vireos was probably growing or stable, but that currently the population is not producing enough young to replace adult mortality (Woodworth 1995). An increase in nest predation rates might also cause such a decline. However, most Puerto Rican Vireo nest predation events in Guánica were caused by avian predators (Woodworth 1995), and there is no evidence that numbers of avian nest predators in Guánica have increased over the time scale of the mist netting study (Faaborg and Arendt, unpub. data). Furthermore, population models have shown that even with the current predation rates, an unparasitized population would sustain itself (Woodworth 1995). Finally, environmental factors can affect fecundity. Faaborg and Arendt (1992) have shown fairly large fluctuations in populations as a result of rainfall variation since 1973, but the recent period has not shown either severe drought or hurricanes. In addition, insectivorous birds are generally least affected by drought, and other insectivores (such as the Puerto Rican Flycatcher (*Myiarchus antillarum*) and Adelaide's Warbler (*Dendroica adelaidae*)) did not show declines during this period.

A decline in numbers of vireos might also be caused by an increase in adult mortality or emigration. In open population models, death and permanent emigration are indistinguishable (Pollock et al. 1990), although in either case, the absence of vireos from previously occupied territories supports a population decline. As discussed above, there is no evidence that survival during this period was affected adversely by drought or hurricanes. Predation on adults appears to be relatively low; in only two of 98 active nesting attempts (with over 900 exposure days) was the incubating adult taken by a predator. Female songbirds are more likely than males to disperse, particularly following nest predation (Jackson et al. 1989). Thus, permanent, or at least long-term, emigration may be a female's response to nest predation or nest failure due to cowbird parasitism. On the other hand, the energetics of building as many as six nests

and laying multiple clutches may lead to increased mortality in Puerto Rican Vireo females, as has been suggested in the Black-capped Vireo (*Vireo atricapillus*; Gryzbowski 1995).

The steepness of the observed population decline in the 1990s could reflect increased mortality, as birds that maintained populations in the 1980s reached maximum age, or there may be an emigration component at work. It is also likely to be due to an increase in the local cowbird population. Censuses and net lines operated in the study sites during the breeding season in the late 1960s and early 1970s rarely recorded cowbirds (Faaborg 1980, Kepler and Kepler 1970), although they occurred elsewhere on the island (Wiley 1985, Perez-Rivera 1986). Seven censuses in Guánica Forest conducted during the breeding season of 1969 detected only four Shiny Cowbirds in 672 km of trail (Kepler and Kepler 1970). A net line operated in July of 1981 caught no cowbirds, and only a single bird was observed during a visit in June of 1983 and in a net line in winter of 1988. In contrast, cowbirds are now common during the breeding season, as Shiny Cowbirds were detected at 27% of 176 unlimited-radius point counts conducted throughout the forest during the 1993 breeding season (Woodworth 1995).

The breeding status of the Puerto Rican Vireo outside of Guánica is not well known. Although it occurs throughout much of the island, occupying forests and brushy pastures (Raffaele 1989), so does the Shiny Cowbird. Data from an ongoing study in successional pastures in and around Cabo Rojo National Wildlife Refuge (CRNWR) suggest that Puerto Rican Vireos may also be in trouble outside of Guánica. In over 2000 h of mist netting in the CRNWR, we have captured only one Puerto Rican Vireo, whereas in similar habitat nearby, in an area known as Pitahaya, we have had capture rates of Puerto Rican Vireos similar to those found in Guánica in the early 1970s (3 per net line). One factor that may account for this difference is extensive Shiny Cowbird eradication efforts in the Pitahaya area as part of ongoing efforts to save the endangered Yellow-shouldered Blackbird (*Agelaius xanthomus*).

More information on reproductive success of vireos in other habitats needs to be gathered to see if this population collapse is island wide or confined only to Guánica. Although vireo populations appear to be declining in Guánica Forest, there are still many vireos present, so there is time to evaluate the problem and determine what can reverse these current trends.

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LITERATURE CITED

Cruz, A. and C. A. Delannoy. 1984. Ecology of the Elfin Woods Warbler (*Dendroica angelae*) II. Feeding ecology of the Elfin Woods Warbler and associated insectivorous birds in Puerto Rico. Carib. J. Sci. 20:153–162.

Faaborg, J. 1980. Further observations on ecological release in Mona Island birds. Auk 97:624–627.

———. In press. Bird population monitoring in Puerto Rico using mist nets: general patterns and comparisons with mist nets. Pp. *in* Proceedings of the Mist Net Symposium. (C. J. Ralph and W. Peach, eds.) U.S. Forest Service Gen. Tech. Report, Albany, California.

——— and W. J. Arendt. 1992. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: a 15-year study. Ornithologia Caribena 3:1–10.

——— and ———. 1995. Survival rates of Puerto Rican birds: are islands really that different? Auk 112:503–507.

Grayce, R. L. 1957. Range extensions in Puerto Rico. Auk 74:106.

Grzybowski, J. A. 1995. Black-capped Vireo (*Vireo atricapillus*). *In* The Birds of North America, No. 181 (A. Poole and F. Gill, eds.) The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Jackson, W. M., S. Rohwer, and V. Nolan Jr. 1989. Within-season breeding dispersal in Prairie Warblers and other passerines. Condor 91:233–241.

Kepler, C. B. and A. K. Kepler. 1970. Preliminary comparison of bird species diversity and density in Luquillo and Guánica forests. Pp. 183–186 *in* H. T. Odum and R. F. Pigeon (eds.). A tropical rain forest: a study of irradiation and ecology at El Verde, Puerto Rico.

Perez-Rivera, R. A. 1986. Parasitism by the Shiny Cowbird in the interior parts of Puerto Rico. J. Field Ornithol. 57:99–104.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildl. Monogr. 107.

Raffaele, H. A. 1989. A guide to the birds of Puerto Rico and the Virgin Islands. Princeton Univ. Press, Princeton, New Jersey.

Remsen, J. V. Jr. and D. A. Good. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. Auk 113:381–398.

Terborgh, J. and J. Faaborg. 1973. Turnover and ecological release in the avifauna of Mona Island, Puerto Rico. Auk 90:759–779.

WILEY, J. W. 1985. Shiny Cowbird parasitism in two avian communities in Puerto Rico. Condor 87:165–176.

WOODWORTH, B. L. 1995. Ecology of the Puerto Rican Vireo and Shiny Cowbird in Guánica Forest, Puerto Rico. Ph.D. diss., Univ. of Minnesota, Minneapolis, Minnesota.